DUMONT

TYPE 405 & 405R

VACUUM-TUBE VOLTMETERS

Operating and Maintenance Manual

Allen B. Du Mont Laboratories, Inc.
INSTRUMENT DIVISION
760 BLOOMFIELD AVENUE, CLIFTON, N. J., U. S. A.

TYPES 405 AND 405-R

VACUUM-TUBE VOLTMETERS

OPERATING AND MAINTENANCE MANUAL

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INSTRUMENT DIVISION
760 BLOOMFIELD AVENUE, CLIFTON, NEW JERSEY

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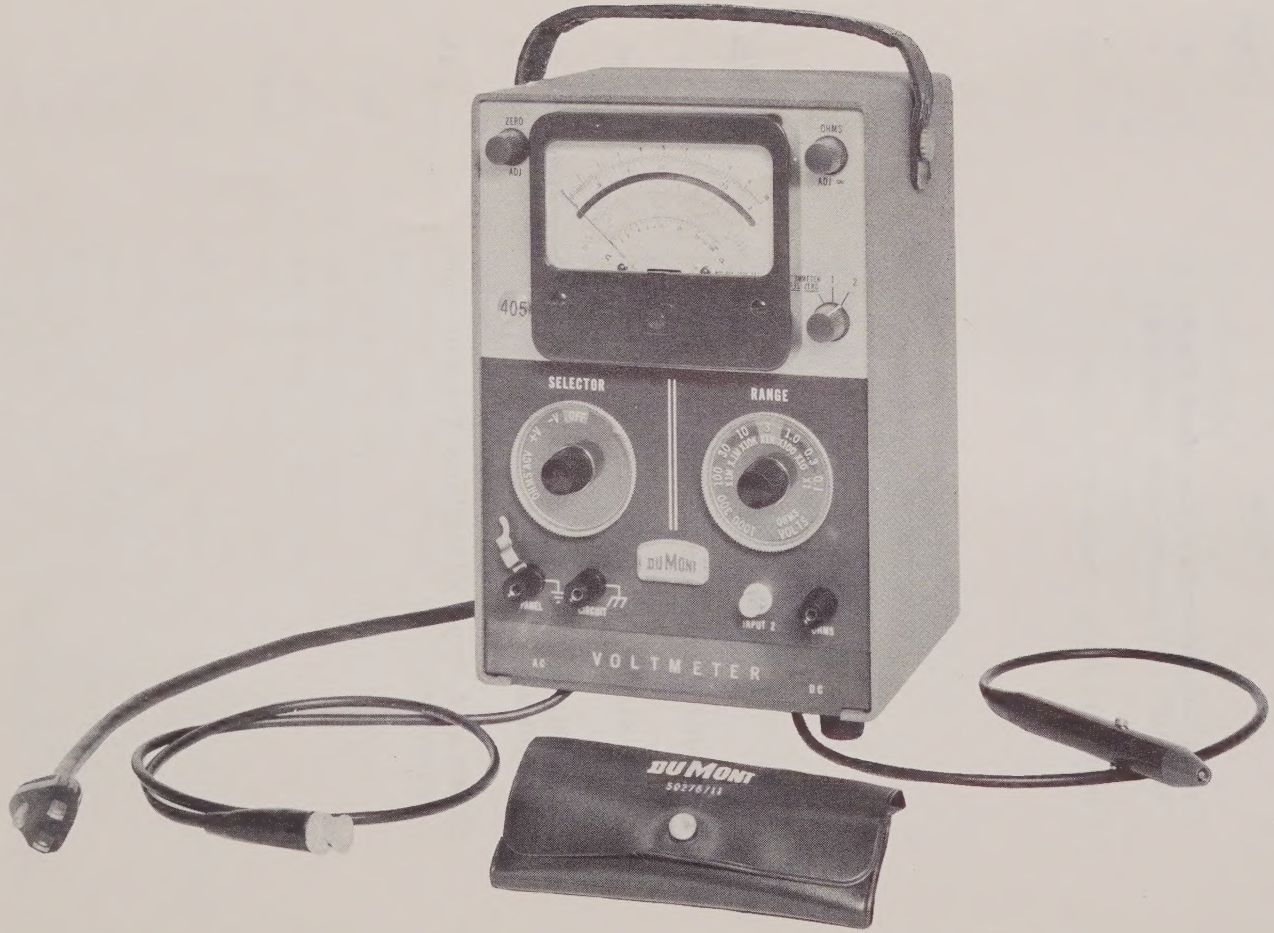


FIGURE 1-1. TYPE 405 VACUUM-TUBE VOLTMETER

SECTION 1

TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instruction contains information on both the Type 405 (bench model) and Type 405-R (rack mounted) Vacuum-tube Voltmeters. Electrically, the two types are identical; mechanically, they differ only in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 405 pertain also to the Type 405-R.

1-2. PURPOSE

The Type 405 Vacuum-tube Voltmeter is a portable instrument designed to measure dc voltages from 0.1 volt full scale to 1000 volts full scale and ac voltages from 0.1 volt full scale to 300 volts full scale. It operates in the frequency range of 20 cycles/second to 700 megacycles/second using proper probes to cover most combinations of voltage and frequency. It will also measure resistance from 0.5 ohm to 500 megohms.

1-3. FEATURES

Scale calibration for the ac measurements is in terms of the rms value of a pure sine wave. On non-sinusoidal high-duty-cycle waveforms the instrument reads 0.707 of the positive peak.

A front-panel jack and switch are provided to facilitate dual-input performance on ac or dc. Circuit ground is isolated from chassis ground to facilitate differential or off-ground input for dc measurements. The amplifier output is available from a jack at the rear. A meter zero position on the Dual Input Switch enables the user to adjust the zero control without shorting out the Input Probes.

A compartment is provided at the bottom of the instrument to store the probes and the probe kit. Cable entry holes permit the compartment door to be closed while the probes are in use.

All operating controls are located on the front panel. The meter movement is illuminated with mirror backing and knife edge pointer. All calibration controls, the fuse, and the output jack are accessible through a door at the rear of the instrument.

1-4. EQUIPMENT COMPLEMENT

The Type 405/405-R is supplied with a captive dc probe and two of the following ac probes: Type 2650 UHF Probe, Type 2651 VHF Probe, and Type 2652 Attenuator Probe.

The following accessories are also available:

a. Type 2653 Probe Cable -- alternate cable for use at INPUT 2.

b. Type 2654 DC Probe -- for use at INPUT 2 with the Type 2653 Cable.

c. Type 2656 Retractile Probe Housing -- for use with ac or dc probes.

d. Type 2657 Coaxial Tee Adapter -- for use with UHF or VHF Probes.

The instrument is supplied with a kit containing:

1	Red test lead
1	Black test lead
2	Spade lugs
2	Alligator clips
2	Small test prods
4	Large test prods
2	Banana plugs

All tips are adaptable to either the ac or dc probes or the leads.

1-5. TECHNICAL SUMMARY

The electrical and physical characteristics of the Type 405 and Type 405-R are listed in Table 1-1 which follows.

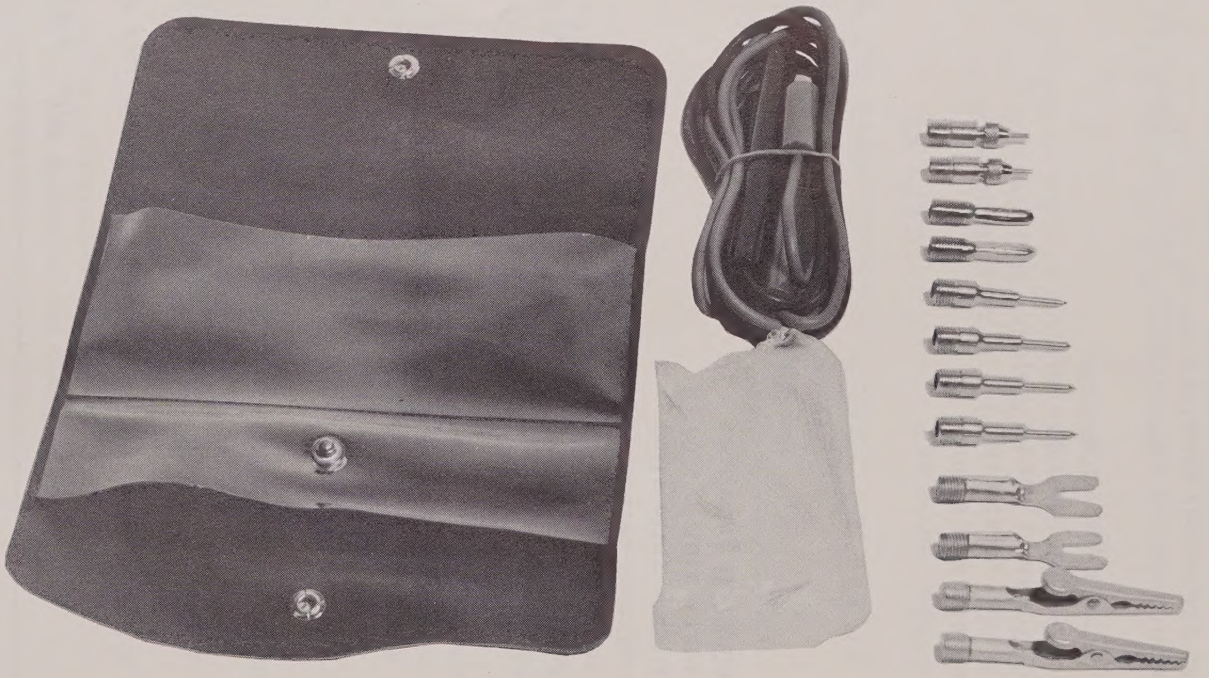


FIGURE 1-2. PROBE KIT

TABLE 1-1

TECHNICAL SUMMARY

DU MONT TYPES 405 AND 405-R VACUUM-TUBE VOLTMETERS

1. DC OPERATION	
a. Volts Full Scale	0.1, 0.3, 1, 3, 10, 30, 100, 300, 1000
b. Accuracy	±2% of full scale on all ranges
c. Input Resistance	120 megohms minimum on all ranges
d. Input Capacitance	Approximately 2 uuf
e. Drift	After 30 minutes warmup less than 5 millivolts during any one-hour period at constant ambient temperature and line voltage.
f. Line Voltage	Power line variations from 103 volts to 127 volts will not cause variation of the indicated voltage in excess of ±5 millivolts after stabilization. Approximately 70% of this error can be corrected by resetting the ZERO ADJ control.
2. AC OPERATION	
a. Volts Full Scale	0.1, 0.3, 1, 3, 10, 30, 100, 300
	The Type 2650 UHF and Type 2651 VHF Probes are usable from 0.1 to 30 volts full scale. The Type 2652 Attenuator Probe is usable for full scale voltages of 100 and 300 volts (read on the 10 and 30-volt ranges)only.
b. Input Impedance	The ac input impedance is a function of both frequency and voltage level for low-frequency use.
	At high frequencies the input capacitance is approximately 4 uuf for the VHF and UHF Probes. The Attenuator Probe has an input resistance of 1 megohm with an input capacitance of approximately 2 uuf.

TABLE 1-1. TECHNICAL SUMMARY (Continued)

c. Drift	After 30 minutes warmup less than 5 millivolts during any one-hour period for voltages read on the linear ranges with the instrument operating at constant ambient temperature and line voltage. Drift on the non-linear ranges is proportionately greater.
d. Line Voltage	Power line variations from 103 to 127 volts will not cause variation of the indicated voltage in excess of ±5 millivolts after stabilization for voltages read on the linear ranges. Variation on the non-linear ranges is proportionately greater. Approximately 70% of this error can be corrected by resetting the ZERO ADJ control.
3. RESISTANCE RANGES	There are seven calibrated ranges from R times one ohm to R times one megohm. Calibrations on the meter scale are from 0.5 continuously to 500.
4. PROBES	
a. General	Three ac probes are designed for use with the Type 405/405-R. They attach to a captive ac probe cable by use of a BNC connector.
	CAUTION Application of a negative dc step voltage or impulse in excess of 150 volts may damage the crystal in the UHF or VHF probes. Maximum High Frequency response requires use of the Type 2657 Tee Adaptor with UHF or VHF Probes.

TABLE 1-1. TECHNICAL SUMMARY (Continued)

b. Accuracy	The calibration accuracy is ±3% of full scale for sine waves from the low frequency specified to 1 megacycle. From 1 megacycle to the upper limit specified ±1 db from the published response curve
c. Type 2650 UHF Probe	
1) Full scale voltage	0.1, 0.3, 1, 3, 10, and 30 volts
2) Frequency response	From 10 kilocycles to over 700 megacycles
d. Type 2651 VHF Probe	
1) Full scale voltage	0.1, 0.3, 1, 3, 10, and 30 volts
2) Frequency response	From below 60 cycles to over 100 megacycles at a voltage level of 0.3 volt or higher. At voltage levels below 0.3 volt, the frequency response may drop to 30% down at 60 cycles
e. Type 2652 Attenuator Probe	
1) Full scale voltage	100 and 300 volts (read on the 10 and 30-volt ranges)
2) Frequency response	±1 db from below 60 cycles to over 5 megacycles. A trimmer adjustment, accessible through the probe body, enables the user to adjust the compensated attenuator to be accurate at even higher frequencies.
5. PRIMARY POWER REQUIREMENTS	
a. Line Voltage	115 volts ±10% or 230 volts ±10%
b. Line Frequency	50 to 400 cycles per second
c. Power Consumption	40 watts
d. Fuse Protection	0.5 amperes slow-blow fuse for 115 volts or 0.3 ampere slow-blow fuse for 230 volts

TABLE 1-1. TECHNICAL SUMMARY (Continued)

PHYSICAL CHARACTERISTICS		
	Type 405	Type 405-R
Height	11-3/4 inches (29.84 cm)	5-1/4 inches (13.33 cm)
Width	8-1/8 inches (20.63 cm)	19-1/2 inches (49.53 cm)
Depth (over-all)	7-1/2 inches (19.05 cm)	9-1/4 inches (23.5 cm)
Weight	12 pounds (5.443 kg)	15 pounds (6.804 kg)

SECTION 2

OPERATION

2-1. GENERAL

The Du Mont Types 405 and 405-R Vacuum-tube Voltmeters are shipped with all tubes in place and ready to operate. Since these instruments are portable, no special installation procedure is required. The -R model is adapted for mounting the instrument in a standard relay rack or cabinet.

2-2. FRONT AND REAR-PANEL FACILITIES (TABLE 2-1)

The front and rear-panel markings are essentially self explanatory, and after carefully studying Table 2-1, the operator will find it possible to master the controls with a minimum of practice.

TABLE 2-1

FRONT AND REAR-PANEL FACILITIES

NAME	FUNCTION
FRONT PANEL	
SELECTOR	Switch: Applies power to the unit and selects the quantity to be measured. When the switch is moved from the OFF position, the meter scale is illuminated and the Du Mont indicator lights.
RANGE	Switch: Selects the proper operating range for measurement of ac voltage, dc voltage or ohmic resistance.
ZERO ADJ	Potentiometer: Adjusts the meter pointer to 0 when the input is shorted to ground either by shorting the probe output to ground or by turning the INPUT switch to the meter zero position. The INPUT switch does not function in the OHMS position.
OHMS ADJ	Rheostat: Adjusts the meter pointer for full-scale deflection when the SELECTOR switch is in the OHMS position and the OHMS input is open.
INPUT (Meter zero, 1, 2)	Switch: Selects the desired input when two inputs are simultaneously connected to the instrument. The INPUT switch does not function in the OHMS position. In the spring loaded METER ZERO position, the inputs are disconnected and the instrument is shorted through a dummy load so that the ZERO ADJ control can be set without having to disturb the probes.
PANEL	Binding post: Cabinet ground. A black lead is provided in the Kit to be used for ground connections.

TABLE 2-1. FRONT AND REAR-PANEL FACILITIES (continued)

NAME	CONTROL
FRONT PANEL	
CIRCUIT	Binding post: Circuit ground. A metal strap is provided connected to PANEL ground. When an off-ground measurement is to be made, the strap is removed and the measurement is made between the captive probe (INPUT 1) and circuit ground.
INPUT 2	BNC coaxial connector: Connects a second input to the unit for convenience in comparing two measurements. Used in conjunction with the INPUT 1-2 switch.
OHMS	Binding post: Input for resistance measurements. A red lead is provided in the Kit for input connection. Resistance measurement is made from the OHMS binding post to CIRCUIT ground.
REAR PANEL	
OUTPUT	Jack: When a standard three-conductor phone plug is inserted into the OUTPUT jack, the meter movement is disconnected and is replaced by the load connected across the plug.
0.1, 0.3, and 1.0 DC; 0.1, 0.3, 1.0, and 3.0 AC	Calibration service adjustments: These adjustments have been set at the factory and normally will not require readjustment. The complete calibration adjustment procedure is given in Section 4, Maintenance.

2-3. ENERGIZING THE EQUIPMENT

The power cable has three conductors. The round conductor is connected to the instrument panel ground. A two-terminal adaptor is provided for connecting receptacles which do not have a ground terminal. To place the instrument in operation, plug the power cord into the proper power source and turn the SELECTOR switch to +V or -V position. Allow about ten minutes for the instrument to warm up.

2-4. DC MEASUREMENTS

1. Place SELECTOR switch in the +V position to measure positive voltage or in the -V position to measure negative voltage.

2. Rotate the RANGE switch to the range which includes the voltage to be measured.

3. Short circuit the input to circuit ground with the dc probe, or switch to the METER ZERO position, and use the ZERO ADJ control to zero the meter.

4. Connect the dc probe and circuit ground across the circuit to be measured. A variety of probe tips are available in the Kit provided. Select the most appropriate tip for the measurement to be made.

2-5. AC MEASUREMENTS

1. Place SELECTOR switch in ACV position.

2. Rotate RANGE switch to the range which includes the voltage to be measured.

3. Short circuit the input to circuit ground with the ac probe, or switch to the METER ZERO position, and use the ZERO ADJ control to zero the meter.

4. Connect the proper ac probe to the point in the circuit at which a measurement is to be made. The clip lead on the probe should be connected to the ground side of the circuit being measured. If desirable, at low frequencies the ground connection may be made directly to the CIRCUIT ground terminal.

CAUTION

Application of a negative dc step voltage or impulse in excess of 150 volts may damage the crystal in the UHF or VHF probes.

5. At high frequencies the length and arrangement of the ground connection can affect the voltmeter reading since the probe resonant frequency is a function of the inductance in the ground loop. It is therefore necessary to keep the ground connection as short as possible. At frequencies above 100 Mc use of the Type 2657 Tee connector is recommended.

6. For voltages up to 30 volts rms the VHF or UHF probe should be used. For higher voltages, the Attenuator Probe must be used.

7. When the Attenuator Probe is used on the 100-volt range, the RANGE switch should be on the 10-volt range. Similarly, for the 300-volt range, the RANGE switch should be on the 30-volt range.

8. When changing probe types it may be necessary to recalibrate the ac range especially the more sensitive ones. The instrument has been calibrated for use with the VHF if supplied, otherwise it is calibrated for use with the UHF probe.

2-6. RESISTANCE MEASUREMENTS

1. Place SELECTOR switch in the OHMS position and rotate RANGE selector switch to the desired range.

2. Short circuit the ohms binding post to circuit ground and adjust the ZERO ADJ control for the meter to read zero. The red lead in the Kit is the ohmmeter lead and the black lead is the ground lead.

3. Unshort the input and adjust the OHMS ADJ ∞ control to read infinity.

4. Connect the ohmmeter lead and ground lead across the circuit where a resistance measurement is to be made. The circuit to be measured should be deenergized prior to any resistance measurements.

2-7. OFF-GROUND VOLTAGE MEASUREMENTS

CIRCUIT ground is isolated from chassis or PANEL ground and is brought out to a binding post on the front panel. A link between CIRCUIT ground and panel ground normally is in place. When off-ground dc voltages are to be measured, the link must be removed and the voltage measurement is made between the probe and the CIRCUIT ground.

The 0.01 uf capacitor (C102) from CIRCUIT ground to PANEL (chassis) ground can be unsoldered to lower the capacitance between grounds to approximately 500 uuf.

> CAUTION
>
> WHEN OFF-GROUND AC MEASUREMENTS ARE MADE, THE TWO SCREWS IN THE PROBE ARE AT CIRCUIT GROUND. A POTENTIAL EXISTS BETWEEN THESE EXPOSED SCREWS AND PANEL GROUND.

Common mode voltage may be as great as 1000 volts dc or 600 volts rms at 60 cps. Off-ground ac measurements may be made at frequencies up to approximately 5 kilocycles before serious common mode errors appear. When common mode voltage is high compared to the voltage to be measured, the instrument should be zeroed with the input probe and the circuit ground connected together and held at the common level.

Off-ground ac measurements may be made at frequencies up to about 5 kilocycles by unsoldering the PANEL ground connection of the ac probe shield at S101 and soldering it to CIRCUIT ground. Voltage measurement is then made between Input 1 and CIRCUIT ground.

2-8. DUAL INPUT

The BNC jack on the panel labelled INPUT 2 is used in conjunction with the INPUT switch. It enables the user to measure voltage at more than one point in a circuit without having to disturb his probes. To utilize this feature a cable such as the Du Mont Type 2653 must be connected to the jack and the probe to be used is then connected to the cable. All three ac probes and the dc probe with BNC connector are available as accessories for use at INPUT 2. When both probes have been connected to the Voltmeter, the INPUT switch determines which probe is connected electrically into the circuit.

NOTE

The link between panel and circuit ground must be in place if dual input measurements are to be made.

It is recommended that only probes of the same type be used for dual input operation in order to minimize errors that may exist between probe calibrations. If maximum accuracy with the ac probes is required, it is recommended that the calibration for both probes be checked prior to use in this manner. No such check is needed for dc probes.

The instrument will read erroneously if a dc probe is connected to INPUT 2 and the SELECTOR switch is in the AC position, and conversely.

INPUT 2 on the front panel enables the user to make up cables of any convenient length. In this way very long or short probe cables can be used without any modification of the instrument. Care must be taken that the cables do not introduce noise or leakage across the high impedance input circuit.

2-9. USING THE OUTPUT JACK

A standard three-conductor phone plug mates with the OUTPUT jack on the rear of the Voltmeter. When plugged in, the meter movement is replaced by the load across the plug. When used in this manner as an amplifier (or impedance transformer) the Type 405 will deliver one milliampere output maximum into 100 ohms minimum. Maximum power gain is over 60 db. The output is balanced around approximately + 65 volts.

The jack can be used to plug in a one milliampere mechanical recorder. Connecting the Type 405 and a recorder in this manner, the high-input resistance, low drift, and excellent stability of this instrument can be used to monitor slow voltage changes in high-impedance circuits.

If a high-input resistance, voltage-sensitive type recorder is to be used, the jack can be bypassed and connection can be made across the bottom terminals of the two resistors R126 and R128 on the component board. The board is located on the right side of the instrument. In this manner the meter continues to operate normally while the recorder continuously records the voltage appearing at the output.

SECTION 3

THEORY OF OPERATION

3-1. GENERAL (Figure 3-1)

The Type 405 Vacuum-tube Voltmeter consists of a precision attenuator, a dc amplifier, a cathode follower and a power supply as shown in the block diagram of Figure 3-1.

In operation as a voltmeter, a voltage at a high impedance is effectively transformed to a current at a low impedance. This current is used to drive the meter movement.

In operation as an ohmmeter, the resistance to be measured is effectively placed in parallel with a calibrated load across which a voltage has been applied. The change in voltage which occurs is applied to the input of the dc amplifier. The attenuator is the load.

It is recommended that the schematic in Section 5 of this manual be referred to in following the circuit description. For information on service adjustments, refer to Maintenance, Section 4.

3-2. CIRCUIT DESCRIPTION

The cathode coupled paraphase amplifier V101 develops a balanced output which is applied to the cathode follower V102. A potentiometer, R118, adjusts the current of each section of V101 so that the amplifier can be balanced. Potentiometers, R121 and R127, in the circuit of V102 functions in a similar manner. Rheostats in series with the meter enable all ranges to be correctly calibrated.

Plate voltage for the dc amplifier and the cathode follower is developed in a full-wave rectifier connected to one secondary winding of power transformer T101. A capacitor input filter and two regulator tubes V104 and V105 maintain a constant output.

The other secondary winding of T101 is connected to the filament circuit. The filaments of V101 and V102 are connected in series with RT101 to regulate the filament current. The winding is center-tapped to provide 6.3 volts for dial indicator lamps and the filament of V103.

An extra input connector is provided so that two probes can be simultaneously connected to the unit and two measurements can be compared without having to move a probe from one position to another. A switch on the front panel selects the input to be displayed on the meter.

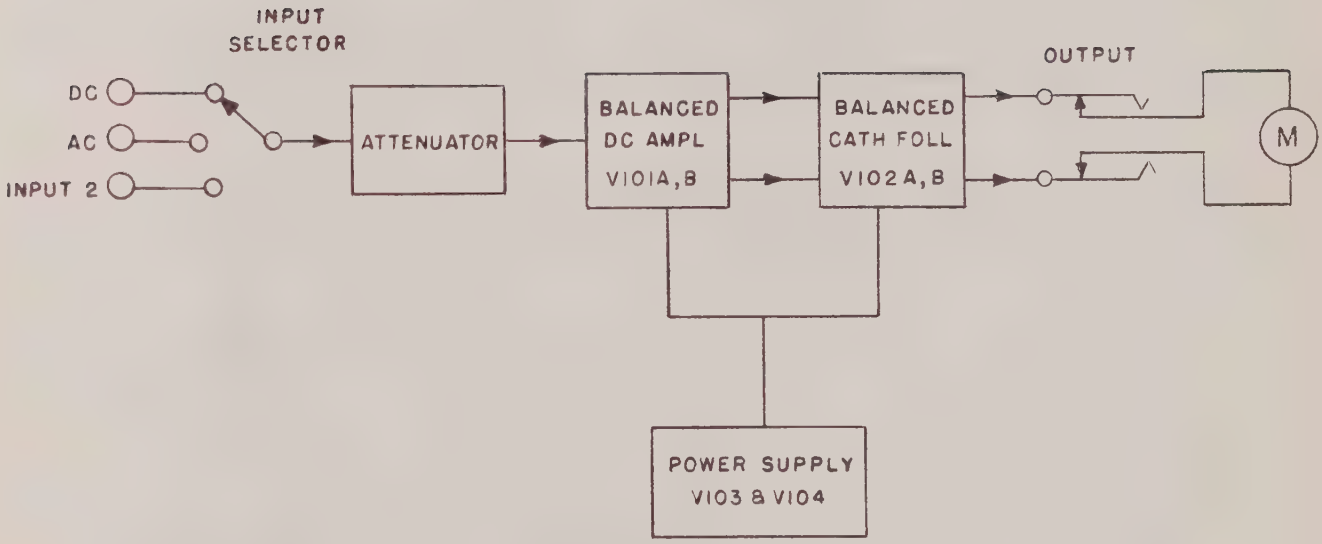


FIGURE 3-1. BLOCK DIAGRAM OF TYPE 405/405-R VACUUM-TUBE VOLTMETER

Circuit ground is insulated from chassis ground and is brought out to a binding post on the front panel. Off ground dc voltages can be measured between the proper probe and circuit ground with common mode voltages up to 1000 volts dc.

Off ground ac voltages at frequencies up to about 5 kilocycles can be measured by unsoldering the chassis ground connection of the ac probe shield at S101 and soldering it to circuit ground. When operated in this manner, a potential exists between the screws on the ac probe and panel ground. Maximum common mode voltage is less at high frequencies.

An output jack is provided so that the instrument can be used as an impedance transformer or a power amplifier. When the Type 405 is operated in this manner the meter is replaced by the load across the plug and the instrument will deliver one milliampere maximum into a minimum load of 100 ohms. Maximum power gain is over 60 db.

SECTION 4

MAINTENANCE

4-1. GAINING ACCESS TO THE CHASSIS AND METER LAMPS

The case of the Type 405 can be removed for routine servicing by removing the two handle screws and the two screws on the bottom which fasten the case to the storage compartment. To gain access to the rack-mounted model (Type 405-R), simply remove one screw from the top and one from the bottom of the dust cover; both screws are located in the center near the front panel.

The meter illuminating lamps can be reached by extracting the two screws on the front of the meter and removing the plastic meter cover.

Before removing V101 or V102 the instrument should be turned off. Since the heaters of these tubes are in the current regulator circuit, pulling out one will cause the voltage on the other to rise excessively.

4-2. LOCATION OF SERVICE ADJUSTMENTS AND TEST POINTS

The Calibration Service Adjustments are accessible behind the rear door of the instrument. With the instrument cover removed, the Test Points and remaining Service Adjustments are accessible at a side component board. Refer to the schematic drawing (9800 1401-4) for the location and identification of these Test Points and adjustments.

4-3. RECALIBRATION PROCEDURE

a. GENERAL

The Types 405 and 405-R Vacuum-tube Voltmeters have been properly adjusted at the factory and in normal operation will require a minimum of maintenance. When tubes or components have been changed, or when recalibration is desired in order to obtain maximum accuracy, the procedure outlined in the paragraphs below should be followed.

b. CHECKING SUPPLY VOLTAGES

1. Warm up

Allow the instrument to warm up at least 30 minutes with the cover on, the rear door closed, and at the line voltage and frequency of normal operation.

2. Check heater voltage

   The heater voltage is checked at Test Point TP108 and should measure between 5.2 and 5.6 volts. If a change in line voltage of 10% causes the heater voltage to change more than 0.1 volt, replace RT101 (9-4D).

3. Check regulated voltages

   Rotate the SELECTOR switch to the OHMS position and check the regulated voltages over the line voltage range ±10%. The -150-volt output is checked at Test Point TP107 and the +150-volt output at Test Point TP106.

c. SET UP THE AMPLIFIER

1. Set INPUT switch to 1, SELECTOR switch to +V, and RANGE switch to 0.1 volt full scale.

2. Remove the cover and make sure that the link between PANEL and CIRCUIT ground is in place.

3. Short the input of the DC Probe to ground. Adjust ZERO ADJ on the front panel until the meter reads zero.

4. Monitor the cathode voltage of V102 at the lower terminal of resistors R126 and R128 on the component board. It should indicate approximately +65 volts when V102 CATH ADJ (R121) is properly set and with the meter zeroed.

5. Short V102A GRID (TP102) to V102B GRID (TP103) at the component board. Adjust V102 BAL (R127) until the meter reads zero. Remove the short.

6. Check the transfer error between positive and negative readings of the same voltage on the 1.0-volt range. If the error differs from the larger reading by ±0.5%, readjust V102 CATH ADJ until the transfer error is within this range.

7. Replace the cover.

d. SETTING THE DC RANGES

1. With the instrument set to measure 0.1 volt full scale, check that the ZERO ADJ is set properly.

2. Apply 0.1 volts from an accurate dc voltage source.

   NOTE: The accuracy of the dc voltage source should be at least ten times the accuracy desired of the Type 405/405-R.

3. Adjust 0.1 VDC (R133) behind the rear door until the meter reads full scale.

4. Reverse the dc voltage source and check the reading. If positive and negative readings differ, balance the error by re-adjusting 0.1 VDC (R133). If the instrument cannot be adjusted by R133 to read 0.1 volt on the 0.1 VDC range, refer to paragraph 4-4, Special Trouble Shooting Hints.

5. Repeat the above procedure for 0.3 volt and 1.0 volt inputs by adjusting 0.3 VDC (R131) and 1.0 VDC (R132) respectively for full scale reading.

e. SETTING THE AC RANGES

1. Using the UHF or VHF probe, set ZERO ADJ with the probe input shorted to ground. Set up the Type 405/405-R to measure 0.1 volts ac.

2. Apply 0.1 volts ac from an accurate sinusoidal ac source at a frequency in mid-range (1 Kc to 100 Kc for VHF Probe, 100 Kc to 500 Kc for UHF Probe).

3. Adjust 0.1 VAC (R134) for full scale accuracy.

4. Repeat the above procedure for 0.3 volts, 1.0 volts and 3.0 volts input by adjusting 0.3 VAC (R135), 1.0 VAC (R136), and 3.0 VAC (R137) respectively for full scale reading.

5. The instrument is now recalibrated.

4-4. SPECIAL TROUBLE SHOOTING HINTS

a. AMPLIFIER MAINTENANCE

If the instrument cannot be adjusted to read full scale with 0.1 volts on the 0.1 VDC range, or if the linearity is very poor, check the setting of V102 CATH ADJ (R121). By controlling the plate voltage of the input amplifier, the V102 CATH ADJ (R121) sets all the operating voltages for both amplifiers and adjusts the input bias for minimum transfer error.

NOTE: If the V102 CATH ADJ (R121) setting has been changed, the recalibration procedure for setting up the amplifier and ranges should be repeated.

Rarely should the 6SU7GTY require replacement. If this tube does fail and a replacement is not immediately available, a 6SL7 may be used as a direct replacement with some loss in performance likely.

Occasionally, on the most sensitive range, application of voltage will cause the meter needle to overshoot and then drift slowly back to the proper setting. This condition does not affect the accuracy of the instrument. In many instances, it will disappear as the 6SU7GTY tubes age.

Specially selected tubes are not required in this instrument, however, a tube with exceptionally poor static or dynamic unbalance may result in improper gain or linearity. If adjustment of the V102 CATH ADJ does not result in proper operating conditions, replace the ECC82/12AU7.

b. PROBE MAINTENANCE

Abuse of the probes, subjecting them to excessive voltage or temperature may result in damage and deterioration of diode performance. After extended life, the back resistance and the efficiency of the probe diodes will decrease. The diode should have a back resistance in excess of 1 megohm when 1.5 volts are across it.

If a probe appears to be defective, it should be checked as follows:

1. Remove the two fillister head screws and slide the sleeve off the probe body.

2. Inspect the components for damage or open connection.

3. Measure the back resistance of the diode (DR313).

4. If the diode must be replaced, use a low wattage soldering iron and exercise great care in soldering in the new diode. DO NOT OVERHEAT since heat can easily damage the diode or associated components.

5. Always recalibrate the ac range when a diode is replaced.

6. It is recommended that the 405 Vacuum-tube Voltmeter be returned to the Du Mont Instrument Service Department for any service not covered in the Manual.

SECTION 5

ELECTRICAL PARTS LIST AND SCHEMATIC

TYPE 405/405-R VACUUM-TUBE VOLTMETER

5-1. PARTS LIST FOR TYPE 405/405-R VTVM

Symbol	Part Number	Description
		CAPACITORS
C102	0313 4570	ceramic, 0.01 uf, +100 -0%, 1000 V
C103	0315 3750	ceramic, 0.005 uf, +100 -0%, 500 V
C104 to C107	0312 2700	ceramic, 0.01 uf, +100 -0%, 500 V
C108	0313 7620	paper, 2 uf, +20 -0%, 600 V
C109	0315 2010	ceramic, 150 uuf, ±20%, 500 V
C111 to C113	0315 2010	ceramic, 150 uuf, ±20%, 500 V
C114	0315 3750	ceramic, 0.005 uf, 500 V
		FUSES
F101	1100 0930	0.5 ampere, slow blow (115 V operation)
	1100 0910	0.3 ampere, slow blow (230 V operation)
		LAMP
DS 101	1200 9031	incandescent, miniature bayonet, 150 ma, 6.3 V
		RECEPTACLES
J101	0902 9080	1 female contact, BNC Type UG-625/U
J102 to J104	5101 2551	post, binding, black
J105	0905 0390	jack, telephone
		METER
M101	2800 2192	1 milliampere full scale (No. 47 frosted lamps, DS 102 and DS 103 supplied as integral part of meter)
		CONNECTORS
P102	0905 0750	1 male contact, BNC Type UG-88C/U
--	0905 0850	line-plug adapter, polarized, 15 amperes, 125 V

5-1. PARTS LIST FOR TYPE 405/405-R VTVM (Continued)

Symbol	Part Number	Description
		RESISTORS (Resistance values in ohms; K = thousand, M = million. All resistors are fixed, composition ± 1/2%, 1/2 W unless otherwise specified)
R101	0203 6790	20 K, ± 5%, 2W
R102	0203 1440	10 M, ± 5%
R103	0203 6790	20 K, ± 5%, 2 W
R104	0239 0045	film, 49.62 M, 2 W
R105 & R106	0239 0044	film, 25.19 M, 1 W
R107	0239 0118	film, 7.481 M
R108	0239 0117	film, 2.519 M
R109	0239 0116	film, 748.1 K
R110	0239 0039	film, 10 M
R111	0239 0115	film, 251.9 K
R112	0239 0119	film, 100 K
R113	0239 0114	film, 10 K
R114	0239 0113	film, 1 K
R115	0239 0112	film, 100
R116	0239 0111	film, 11.2
R117	0228 5890	film, 75 K, ± 1%
R118	0108 1770	variable, wire-wound, 5 K, ± 10%, 2 W
R119	0228 5890	film, 75 K, ± 1%
R120	0203 0890	51 K, ± 5%
R121	0107 1534	variable, 50 K, ± 20%
R122	0223 7680	film, 4 M, ± 1%
R123 & R124	0228 6230	film, 2 M, ± 1%
R126	0203 6810	24 K, ± 1%, 2 W
R127	0107 1533	variable, 10 K, ± 20%
R128	0203 6810	24 K, ± 1%, 2 W
R129	0108 1710	variable, wire-wound, 1 K, ± 10%, 2 W
R131	0107 1852	variable, wire-wound, 1 K, ± 10%, 2 W
R132	0107 1855	variable, wire-wound, 7500, ± 10%, 2 W
R133 & R134	0107 1851	variable, wire-wound, 500, ± 10%, 2 W
R135	0107 1536	variable, wire-wound, 2 K, ± 10%, 2 W
R136	0107 1856	variable, wire-wound, 10 K, ± 10%, 2 W

5-1. PARTS LIST FOR TYPE 405/405-R VTVM (Continued)

Symbol	Part Number	Description
R137	0107 1853	variable, wire-wound, 2 K, ± 10%, 2 W
R138	0203 0760	15 K, ±5%
R141	0224 4860	wire-wound, 3500, ±10%, 10 W
R142	0203 6040	15, ±5%, 2 W
R143	0203 6030	13, ±5%, 2 W
R144	0222 4570	wire-wound, 10, ±5%, 5 W
R147 to R149	0203 1440	10 M, ±5%
R151	0203 1440	10 M, ±5%
R152	0203 3710	9100, ±5%, 1 W
R153	0203 1400	6.8 M, ±5%
R155	0203 0980	120K
R156	0203 1000	150 K
R157	0203 1030	200 K
R158	0203 1050	240 K
R161	0230 4530	wire-wound, 3 K, ±10%, 3 W
R162	0230 4630	wire-wound, 10 K, ±10%, 3 W
R163	0230 4420	wire-wound, 250, ±10%, 3 W
R 164	0230 4400	wire-wound, 150, ±10%, 3 W
R165	0230 4530	wire-wound, 3 K, ±10%, 3 W
R166	0229 0650	wire-wound, 12,500, ±10%, 3 W
R 167	0230 4550	wire-wound, 4 K, ±10%, 3 W
	REGULATOR	
RT101	0223 5290	current, Amperite 9-4D
	SWITCHES	
S101	0501 3261	rotary, 30, 1 section, 3 positions; spring-loaded fully CCW position; detents next two positions
S102	0501 4701	rotary, 30, 4 sections, 5 positions
S103	0501 4691	rotary, 30, 4 sections, 9 positions

5-1. PARTS LIST FOR TYPE 405/405-R VTVM (Concluded)

Symbol	Part Number	Description
	TRANSFORMER	
T101	2001 2621	power, 115/230 Volts, ±10%, 50-400 cycles/second
	TUBES	
V101	2501 1400	6SU7GTY
V102	2501 1610	ECC82/12AU7
V103	2500 0170	6X4
V104 & V105	2500 9020	OA2WA
	CABLES	
W501	5026 9641	assembly, power, electrical, 3-conductor, #18 AWG, 72 inches
--	5027 8240	rf, coaxial, noise free

5-2. PARTS LIST FOR TYPE 2650 UHF PROBE

Symbol	Part Number	Description
C1	0312 5720	capacitor, ceramic, 500 uuf, 500 V
CR1	2600 6080	crystal, DR313
R1	0239 0039	resistor, fixed, film, 10 M ohms ±1/2%, 1/2 W
R2	0228 7290	resistor, fixed, composition, 1 K ohms, ±10%, 1/4 W
--	3303 3372	assembly, ground lead with alligator clip (3600 4670) attached
--	4201 3652	cover, test probe
--	3303 6912	housing, test probe; included as integral parts of this housing are the spring-loaded brass tip and the modified BNC Type UG-625/U female connector

5-3. PARTS LIST FOR TYPE 2651 VHF PROBE

Symbol	Part Number	Description
C1 & C2	0319 0871	capacitor, ceramic, 0.05 uuf, 500 V
C3	0317 0040	capacitor, ceramic, 47 uuf, ±10%, 500 V
CR1	2600 6080	crystal, DR313
R1	0239 0039	resistor, fixed, film, 10 M ohms, ±1/2%, 1/2 W
R2	0226 0650	resistor, fixed, composition, 100 ohms, ±10%, 1/10 W
--	3303 3372	assembly: ground lead with alligator clip (3600 4670) attached
--	5201 3651	cover, test probe
--	3303 6911	housing, test probe; included as integral parts of this housing are the spring-loaded brass tip and the modified BNC Type UG-625/U female connector

5-4. PARTS LIST FOR TYPE 2652 ATTENUATOR PROBE

Symbol	Part Number	Description
C1	0315 2460	capacitor, composition, 0.68 uuf, ±20%, 500 V
C2	0318 4110	capacitor, variable, ceramic, 3-12 uuf, 350 V
C3	0318 0100	capacitor, ceramic, sub-miniature, 0.025 uf, 200 V
CR1	2600 6080	crystal, DR313
R1	0222 6340	resistor, fixed, film, 900K ohms, ±1%, 1 W
R2	0228 0250	resistor, fixed, film, 106K ohms, ±1%, 1/8 W
R3	0239 0039	resistor, fixed, film, 10M ohms, ±1/2%, 1/2 W

5-4. PARTS LIST FOR TYPE 2652 ATTENUATOR PROBE (Concluded)

Symbol	Part Number	Description
---	3703 3372	assembly, ground lead with alligator clip (3600 4670) attached
---	4201 3653	cover, test probe
---	3303 6913	housing, test probe; included as integral parts of this housing are the spring-loaded brass tip and the modified BNC Type UG-625/U female connector

5-5. TYPE 2653 PROBE CABLE

Description	Part Number
Assembly: consists of 3-foot length of cable (5027 8240) and connectors (0905 0750) attached at each end of cable	0904 1241
Cable, rf, coaxial, 1900 V rms maximum operating voltage, noise free	5027 8240
Connector, 1 male contact, BNC Type UG-88C/U	0905 0750

5-6. TYPE 2656 RETRACTILE PROBE HOUSING

Description	Part Number
Housing, retractile probe	5027 6651
Spring, compression	3004 8501
Stud, thread	6090 9841

5-7. TYPE 2657 COAXIAL "T" ADAPTER

Description	Part Number
Adapter, coaxial T, modified Type "N" connector	0904 1272

5-8. TYPE 2663 PROBE TIPS AND LEADS KIT

Description	Part Number
Kit contains the following:	
a. test lead, red, 44 inches long, 1 inch and 4 inches red bakelite ends	5027 6711
b. test lead, black, 44-1/2 inches long, 1 inch and 4 inches black bakelite ends	
c. spade lugs, 2	
d. alligator clips, 2	
e. test prod, small, needle nose, 2	
f. test prod, large, 4	
g. plug tips, banana type, 2	

5-9. TYPE 2654 DC PROBE

Description	Part Number
Resistor, fixed, film, 10 M ohms, ±1/2%, 1/2 W	02390039
Probe housing	3303 6911
Probe cover	4201 3651
Ground stud	6090 9081

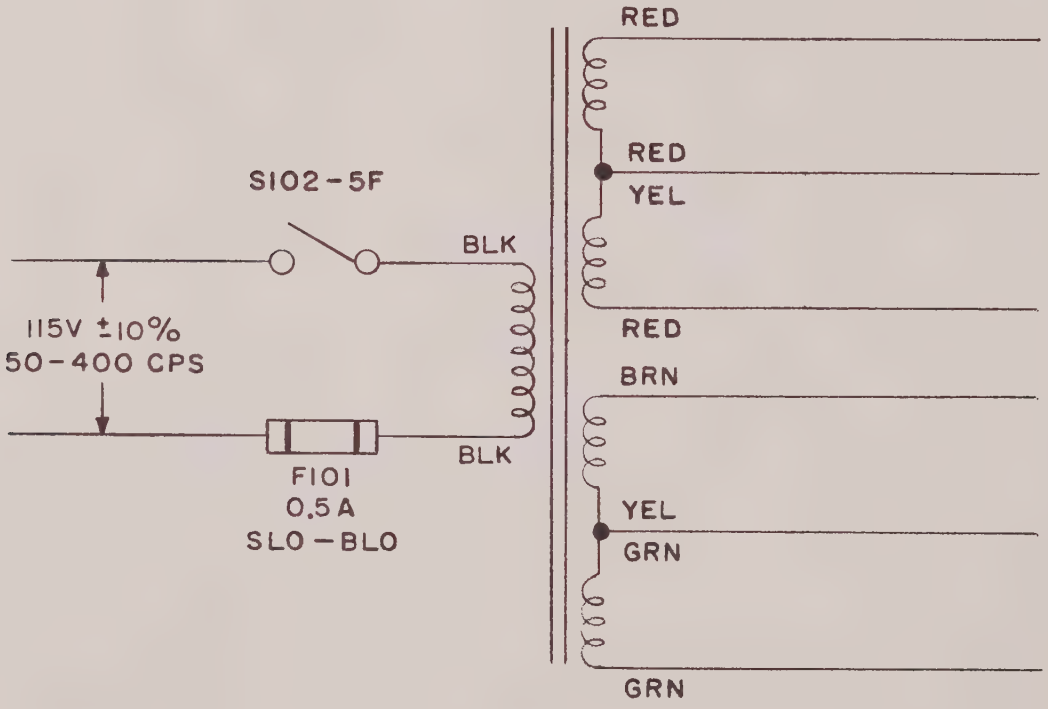
APPENDIX

Two regulated power supplies are available from the following power sources:

a. 50 to 400 cycles/second at either 115 volts, ±10%, or 230 volts, ±10%. This is the circuit shown on the Schematic Drawing 9800 1401-4.

b. 50 to 400 cycles/second at 115 volts, ±10%.

c. On Schematic Drawing 9800 1401-4, the transformer circuit for Paragraph b above is revised as follows:

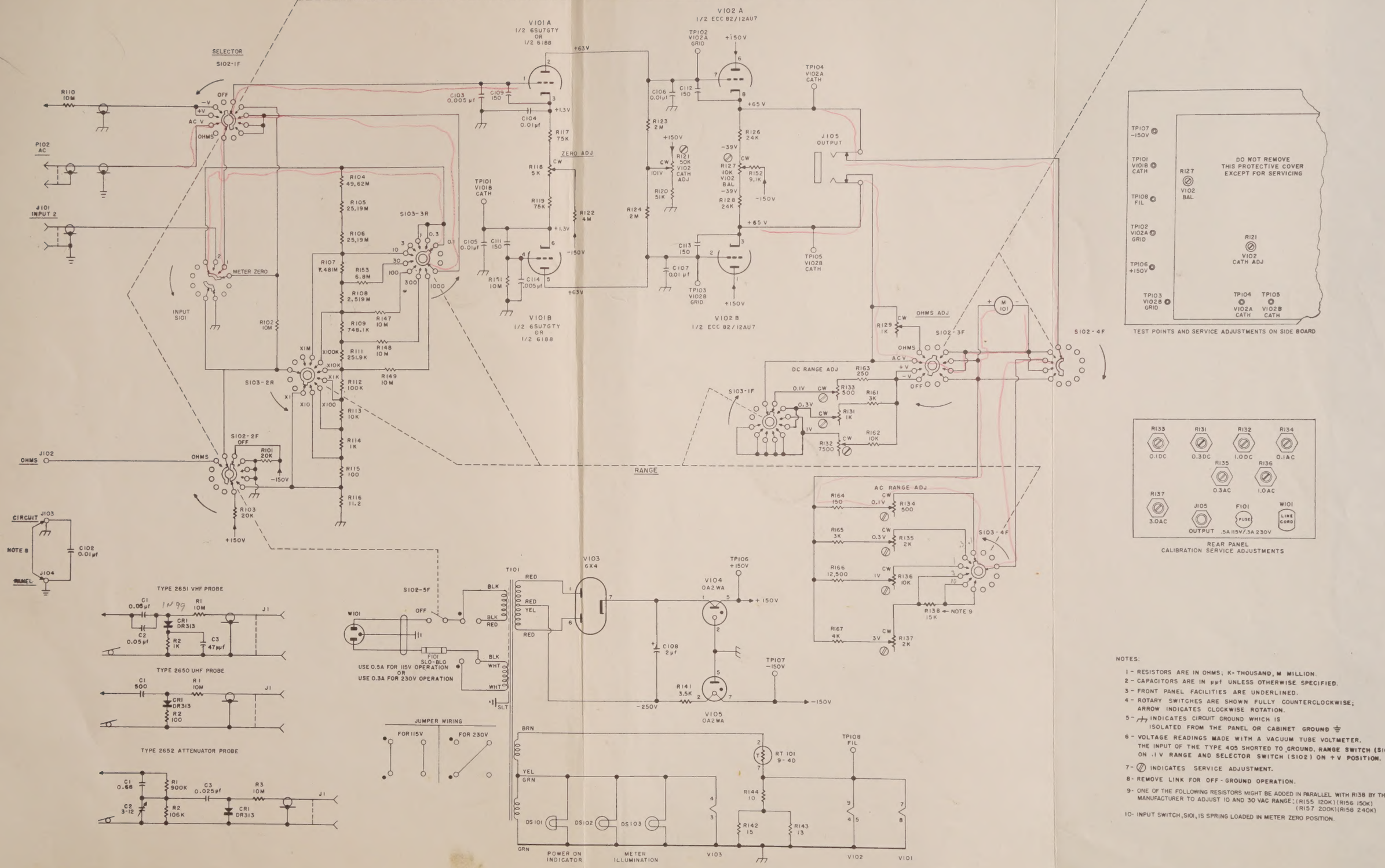


d. The Parts List addition for Paragraph b above is as follows:

	Symbol	Part Number	Description
Add	F101	1100 0930	Fuse, 0.5 ampere, slo-blo
Add	T101	2001 2251	Transformer, power, 115 volts, ±10%, 50-400 cycles/second

APPENDIX (Continued)

	Symbol		Part Number	Description
Delete	R101		0203 6790	Resistor, fixed, film, 20K ohms, ±5%, 2 W
Change	R141	from	0224 4860	Resistor, fixed, wire wound, 3500 ohms, ±10%, 10 W
		to	0211 2280	Resistor, fixed, wire wound, 2500 ohms, ±10%, 5 W



NOTES:

1 - RESISTORS ARE IN OHMS; K= THOUSAND, M MILLION.
2 - CAPACITORS ARE IN µµf UNLESS OTHERWISE SPECIFIED.
3 - FRONT PANEL FACILITIES ARE UNDERLINED.
4 - ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE; ARROW INDICATES CLOCKWISE ROTATION.
5 - ⏚ INDICATES CIRCUIT GROUND WHICH IS ISOLATED FROM THE PANEL OR CABINET GROUND ⏚
6 - VOLTAGE READINGS MADE WITH A VACUUM TUBE VOLTMETER. THE INPUT OF THE TYPE 405 SHORTED TO GROUND, RANGE SWITCH (S103) ON .1 V RANGE AND SELECTOR SWITCH (S102) ON +V POSITION.
7 - Ø INDICATES SERVICE ADJUSTMENT.
8 - REMOVE LINK FOR OFF - GROUND OPERATION.
9 - ONE OF THE FOLLOWING RESISTORS MIGHT BE ADDED IN PARALLEL WITH R138 BY THE MANUFACTURER TO ADJUST 10 AND 30 VAC RANGE: (R155 120K)(R156 150K) (R157 200K)(R158 240K)
10 - INPUT SWITCH, S101, IS SPRING LOADED IN METER ZERO POSITION.